



Multimedia for Learning

Methods and Development

THIRD EDITION

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complex calculations). We discuss these approaches to learning in Chapters 5 (“Hypermedia”), 7 (“Simulations”), 9 (“Tools and Open-Ended Environments”) and 11 (“Web-Based Learning”).

There is room and need for both approaches. In some situations, providing instruction is appropriate; in others, providing the tools for learning is appropriate. More often than not the two should be combined. Dogmatism on either side is unnecessary and unproductive.

The Process of Instruction

In the ongoing debate between constructivist educators and instructivist educators, instruction has been portrayed as an approach whereby knowledge is *given to* people, while learning is an approach whereby people *obtain* knowledge for themselves. Such a distinction is artificial and a misuse of semantics. The two, instruction and learning, almost always go hand in hand, and the term *instruction* should be understood much more generally. Instruction should be the *creation and use of environments in which learning is facilitated*. People certainly can learn completely on their own and without outside instigation. However, in institutions in which learning must be facilitated (such as public schools, universities, or businesses), instruction *is* that facilitation of learning, and it can combine a variety of approaches. Instruction can admittedly be strictly directed or be much more open-ended. Most instruction falls in between. However, to facilitate learning (i.e., to provide instruction) in at least a moderately efficient way, the process must include several essential activities. This section describes our model for successful instruction. According to that model, the following four activities or *phases of instruction* should occur for learning to be effective and efficient:

- Presenting information
- Guiding the learner
- Practicing
- Assessing learning

In contrast to this model, proponents of discovery or constructivist learning might omit the first phase or change the order of the first two phases. Research evidence in favor of discovery learning is usually limited to some learners (usually higher-ability learners) and some kinds of learning (such as problem solving). Our opinion is that discovery learning activities are most beneficial when placed within the context of a larger learning environment with these four activities. That is, guiding the learner can include discovery techniques. But as a complete model for building learning environments, discovery learning has not proved beneficial for most learners and most subject areas.

Presenting Information

The first three phases are based on research on successful classroom instruction (Rosenshine & Stevens, 1986). To teach something new, the instructor must first present information. This may be done in a number of ways. For verbal or pictorial information, an instructor may present rules and examples, show pictures, or provide other nonverbal

information. To teach skills, such as operating a 35-mm camera or doing long division, the instructor can model the skills to be learned. That is, the instructor actually performs the skills so that learners can imitate them.

An important method of presenting information is through example. Thus, in addition to stating the physical rule *force equals mass times acceleration*, the instructor can demonstrate applications of that physical rule, such as a truck accelerating more quickly when it is empty. The skill of long division can be modeled using a variety of numbers in the dividend and the divisor. Most learners require more than one example before they are able to apply a rule or skill.

Presentation of information can be accomplished with any medium, not just with live instructors. It often occurs completely under the control of the learner. When college students read their course textbooks, information is being presented. When factory workers watch videotapes about new equipment, information is being presented. When a learner does library research or engages in any activity to seek out existing knowledge or information, the first phase is occurring.

Guiding the Learner

The first phase, *presenting information*, is instructor or media centered. The second phase, *guiding the learner*, is more interactive and includes both the learner and the medium. For example, having observed a videotape presentation, the learner might now perform under instructor guidance. Again, this means different things depending on the nature of the material. The learner may answer questions about factual information, may apply rules and principles in problem-solving activities, or practice procedural skills. In each case, an instructor (or interactive medium) observes the learner, corrects errors, and gives suggestions or hints. If the learner distorts factual information, an instructor might remind the learner of the correct information, perhaps by repeating it. When the learner performs a skill incorrectly, a computer may model again the procedure or part of it. If a learner demonstrates misunderstanding of concepts or principles, a fellow learner might try to understand the confusion and dispel it.

In the classroom, guidance often takes the form of the instructor asking questions that learners must answer. When a question is answered incorrectly, the instructor may either tell the learner the correct answer or may ask leading questions to help the learner recall the correct information.

When one learns from a book, questions or suggested activities are sometimes included as guidance. But unlike in the classroom, if the learner does not do these correctly, true guidance does not occur. The learner may receive help only at some later time, such as when the instructor checks the learner's work and provides feedback.

Guidance is important in instruction because nobody learns everything from a single exposure. Learners make errors and are frequently unaware that they have. Learners must be made aware of these and correct them. The interactive process of the learner attempting to apply new knowledge, the instructor correcting and guiding, and the learner making further attempts are components frequently omitted in instruction and yet probably the most important.

As previously stated, not all models of teaching begin with the presentation of information. Discovery learning is based on the assumption that learners discover princi-

ples or develop skills through experimentation and practice. There is evidence that for some kinds of information, such as in the sciences or for the development of self-directed learning strategies, learner inquiry and discovery are effective (Derry and Lajoie, 1993; Jonassen, Peck, & Wilson, 1999; White, 1993). For the majority of regular school subjects and most procedural or physical skills, we regard a model that begins with the presentation of information as more efficient and demonstrably more successful (Klausmeier & Feldman, 1975; Koran, 1971; Merrill, 1974). In cases where a discovery approach is believed to have some advantage, we would stress that *guided* discovery (in contrast to undirected, free discovery) is more successful. The discovery activity should be a part of the guidance phase of instruction. It should follow some initial exposure to relevant material. And it usually should be followed by the other phases of instruction.

Practice

Learning is not complete when a learner can do something once or can demonstrate that he or she currently understands the material. The learner must usually be able to perform quickly or fluently, sometimes under conditions of distraction, with few or no errors. Furthermore, we usually want to learn information permanently rather than for a short time. Practicing a skill once or answering a single question does not guarantee retention. Repeated practice is often required to retain information and to become familiar with it.

The third phase, *practice*, is also learner centered. Although an instructor or interactive medium may observe the learner and makes corrections when errors are observed, the emphasis is on the learner practicing and the instructor making only short corrective statements.

Fluency and speed are related but slightly different aspects of well-learned information. To be fluent in a skill not only means doing it quickly, but doing it without thinking about it. To speak French fluently, for example, it is necessary that the correct words come automatically, without thinking. Reading, writing, spelling, arithmetic, driving a car, and countless other skills are almost worthless if not performed in this way.

On the other hand, some information does not require fluency. It does not matter whether one can perform a chemistry experiment or write a critical essay quickly. One need not be able to make decisions about starting a business without thinking about it. It is more important that such things be done carefully and correctly. However, one must at least remember how to do these things. Practice not only enhances speed and fluency but also retention.

Many examples of practice in classroom instruction exist. In elementary school reading instruction, the instructor frequently asks learners questions or requires them to read passages from primers. In arithmetic instruction, workbooks are the most common method of practice. They allow all learners to practice simultaneously rather than having most learners listen while one learner at a time practices. Unfortunately, when a learner makes an error practicing in a workbook, it might never be corrected.

In foreign-language instruction, a common type of practice is flashcards. The learner produces a pile of cards, for example, with French words on one side and equivalent English words on the reverse. The learner then goes through the deck of cards trying to translate the words correctly and receives immediate corrective feedback by looking at the other side of the card.

Assessing Learning

The first three phases just discussed are what most people consider to be instruction. However, we should not assume that instruction is successful for all learners. Rather, learning should be *assessed*, usually with tests or rubrics, which are an important part of the instructional process. These provide information about the level of learning, the quality of teaching, and future instructional needs. Instructors and learners alike place undue emphasis on assessment as a means of assigning grades. Our emphasis in this book is on assessment as a means of guiding instructional decisions—to determine what instruction is needed for which learners.

■ Methodologies for Facilitating Learning

According to the model we have described, the process of instruction includes the presentation of information to learners; guidance of learners' first interaction with the material; learners practicing the material to enhance fluency and retention; and, finally, assessment of learners to determine how well they have learned the material and what they should do next.

This model, though derived from research on successful classroom instruction, can also be applied to interactive multimedia. That is not to say that the computer must fulfill *all* the phases of instruction. Computers are but one element in a learning environment, along with teachers, other learners, and other media. The computer may serve one or a combination of the four phases. It may present initial information after which the learner receives guidance from an instructor and practices using a workbook. One may learn initial information from a lecture, after which the computer is used to practice some parts of the material for fluency. The computer may be used for the first three phases, with assessment being done in traditional ways. In all cases, the four phases of instruction should be present, generally using a combination of media.

When the computer *is* responsible for total instruction, it is important that all four phases be included. This is not always done. It is common, for example, for computer programs intended for practice (drills) to be expected to carry the load of total instruction. When this is attempted, learners can fail to learn what is desired.

In Part II of this book, we discuss eight methodologies of *Interactive Multimedia* (IMM) for the facilitation of learning:

- Tutorials
- Hypermedia
- Drills
- Simulations
- Games
- Tools and open-ended learning environments
- Tests
- Web-based learning

Tutorials are programs that generally engage the first two phases of instruction. They take the role of the instructor by presenting information and guiding the learner in initial acquisition. Hypermedia programs are another methodology for presenting or obtaining information but are designed for a more open-ended or constructivist learning experience. They are less structured than tutorials, thus allowing learners to choose their own paths through the material. Each individual would likely have different paths for different reasons.

Drills and most games typically engage learners in the third phase, helping them to practice for fluency and retention. We use the term *drill* for practice which *repeats* the material to be learned until it is mastered. Drill and game methodologies are often combined for motivational purposes. Some learning games are not repetitious, that is they do not practice to mastery, and so we would not call them drills, but they are nonetheless designed to provide practice in some area.

Simulations are more complicated. A simulation may be used to present information and guide the learner, to guide and practice, to do all three, or to assess a learner's knowledge. However, it is rare for a simulation (or a single lesson of *any* methodology) to provide all four phases of instruction. Most methodologies must be used in conjunction with other programs or media to provide complete instruction. The four phases of instruction typically occur over days or weeks, not a single instructional session.

Simulations may be used for direct instruction or for a more constructivist approach. Many simulations allow users to operate freely within a constrained environment. For example, in a program to simulate a chemistry titration experiment, the user may be allowed to assemble the equipment in a variety of ways or use any amounts of chemicals, but would not be able to use equipment or chemicals not shown. In a physics simulation for learning mechanics, the user could choose from a variety of devices for projecting or dropping objects and measuring their motions. Simulations may also be combined with the game methodology to foster discovery learning.

Games, as we have just said, may be combined with drills or with simulations. But many learning activities use games without being drills or simulations. Games may be used to practice information in a nonrepetitive manner, may be used as a discovery environment, or may be used to integrate learning across a number of subject areas, as is often done with the adventure game genre. Games usually support the third phase, practice, when they are combined with the drill methodology or used in the content integration fashion typical of adventure games. Less frequently, games may be used for guidance or assessment when combined with the simulation methodology.

Tools are computer software that learners use in conjunction with other media or activities for achieving some educational goal. They are by their nature more open ended and flexible. Graphics tools may be used to support drawing in art or graphing in math. Calculation tools may support science or business education. They may be a part of any of the phases of instruction and may support either constructivist or objectivist learning environments.

Open-ended learning environments, like simulations, provide an environment to support exploration. They usually include tool software as well. Although they may be used to foster learners obtaining or creating knowledge, they are frequently an environment in which learners practice the application of new knowledge.

Tests almost always represent the last phase, assessment of what has been learned. An exception is practice tests or quizzes, which are commonly used to foster the practice phase of instruction.

Finally, Web-based learning can be combined with any of these other methodologies (for the Web is essentially a *delivery* medium) though at this time, it is used mostly in conjunction with the hypermedia methodology. Use of the Web can foster any of the phases of instruction.

We devote a chapter to each of these eight approaches, and so it might be assumed that any interactive multimedia lesson must be classifiable as one of them. This is not the case. Many lessons combine methodologies, such as a lesson that begins with a tutorial and then follows with a drill, or a drill that is practiced in the context of a game to make it more enjoyable. In fact, it is rare for a program to use only one methodology. In the eight chapters of Part II, we describe and give examples of the methodologies, analyze their characteristics, and give recommendations for their design. The methodologies that we discuss in this book provide the basic groundwork for understanding and developing good interactive multimedia of either the instructivist or constructivist varieties.

■ Two Foundations of Interactive Multimedia

Before we analyze the methodologies of interactive multimedia, the next two chapters will provide a foundation on which to build the discussion. First, it is important to understand the different theories of learning that underlie all instruction and learning environments. Chapter 2 discusses those underlying issues.

Second, interactive multimedia must be built on sound human factors to be effective. Human factors is the study of the interaction of people with technology. Chapter 3 examines the general issues of screen design, multisensory presentation, types of interactions, learner control, and the facilitation of motivation.

■ Developing Interactive Multimedia

Finally, Part III discusses the various aspects of taking a design to fruition as a complete multimedia product. After a general introduction to development in Chapter 12, Chapter 13 provides a detailed look at how to plan a project properly, including the important issues of knowing the constraints under which you have to work (such as the budget), of keeping the project on track (project management), and of defining the overall standards for the project.

Chapter 14, “Design,” discusses the process of defining the content, structure, and interactions of the multimedia program, and the essential issue of communicating your design ideas accurately to all team members.

Finally, Chapter 15, “Development,” examines the development cycle and revisits project management. We consider production not only of the primary product but also of ancillary pieces, such as learner and instructor manuals. We also provide guidelines for testing your product and validating its effectiveness.

Conclusion

It is useful to lay out our own philosophy with respect to using computers to facilitate learning. First, we believe that there is a real world out there (an objectivist belief) and that people must learn to function appropriately in that world to survive and be successful. Second, we believe that learning is a constructive process whereby each learner observes and interprets reality and creates an understanding of it. Third, we believe that the two points above demand a combination of approaches—recognizing that learning is constructive, but also that there are essential truths to be learned. The fact that learning is constructive does not require that education be constructive. Rather, education should include direct instruction methods, experiential methods, exploration methods, and others.

Designing software that helps people to learn is a difficult and rewarding experience, no matter which philosophical approach you ascribe to. All philosophies share the common goal of having the people learn something useful and meaningful. We encourage you to jump right in and get your own interactive multimedia project underway (a constructivist approach) because you will learn much from the experience. Before you do so (or at least in parallel), we recommend you finish reading this book (a cognitivist approach) because it can save you a great deal of time and anguish by pointing out both well-established good practices, as well as known pitfalls.

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